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Genetic gain through breeding research in protein content and brown rust resistance in semi dwarf wheat varieties

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Abstract
India witnessed Green Revolution with the introduction of semi-dwarf wheat varieties *viz*., Kalyan Sona and Sonalika from CIMMYT Mexico in 1963. With an increase in the wheat yield per unit area, the country became self-sufficient in wheat production. However, even after the green revolution, in India bulk of population below poverty line is the victim of protein malnutrition, because 70% of protein needed by human is met from cereal grains more particularly from wheat. On the other hand, leaf or brown rust, one of the dreaded diseases of wheat is more prevalent in Eastern India. Therefore, the protein content and leaf rust resistance were taken as the major parameters to determine the improvement in these traits through breeding research. The trial was laid down in randomized block design with four replications. The results indicated that K-816 contained the maximum protein content (12.40%), followed by K-9533 (12.30%) and PBW-343 (12.28%) among the 15 varieties including two checks (Kalyan Sona (11.90%) and Sonalika (11.78%). However, their differences in mean values were non-significant over checks. Almost all latest wheat varieties (except HUW-318, Veeri, K-816, Kalyan Sona and Sonalika) have shown a good degree of resistance to leaf rust races. It may be concluded from the present investigation that there has been no significant improvement brought in protein content through breeding research. However, resistance to leaf rust has been appreciated

Keywords: Wheat breeding, protein content, leaf or brown rust resistance

Introduction
Green revolution made a remarkable progress in increasing wheat production in India. With the introduction of semi-dwarf wheat varieties, especially two selections *viz*., Kalyan Sona and Sonalika made out of CIMMYT breeding materials, production of wheat in India rose from 12.0 m.t. in 1965 to 76.3 m.t. in 1999-2000 (Nagarajan, 2005) [14]. This period is most famous an era of 'Green Revolution' in the Indian history. Both Kalyan Sona and Sonalika were ideal in plant type. They possess short plant stature, bold and amber grains, respond to higher doses of fertilizer application (120N: 60P: 50K) and irrigation management (5-6) without lodging. Due to the short maturity duration both fitted well in the "rice-wheat" cropping system which collectively brought "Wheat Revolution". In addition, these varieties were resistant to all the three wheat rust diseases *viz*; stem rust, leaf rust and stripe rust. As a result production of wheat tremendously increased per unit area and time (Choudary and Ali, 2008) [4]. After yield, grain quality, especially protein is a very important character and direly needed for human beings. However, even after the green revolution, in India bulk of population below poverty line is a victim of protein malnutrition, because 70% of protein needed by humans is met from cereal grains. There has been no significant improvement made in the protein content through breeding research because all the newly released high yielding improved varieties are at par in protein content when compared with the first generation semidwarf wheat varieties i.e. Kalyan Sona and Sonalika. Among wheat rusts, brown rust is most widespread, black rust is restricted to Peninsular India, yellow rust to Northern and North-Western regions of India (Thind, 2005) [16]. Each has a number of physiological races such as 32 of stem rust; 24 of leaf rust and 20 of stripe rust. Cultivars that only have race-specific rust resistant genes lose their effective resistance and become susceptible within a few years of release (James, 2013) [10]. It is, therefore, desirable that germplasm exhibiting resistance through non-specific interaction should be used in breeding programs rather than germplasms exhibiting only specific interaction. The foundation varieties Kalyan Sona and Sonalika also broke down their resistance within five years to the leaf (brown) and yellow (strip) rust. These were quickly replaced by new semi-dwarf wheat varieties. Hence, the present investigation was undertaken to generate data to derive concrete and conclusive evidence to prove the level of improvement in grain quality (protein) characteristics and the level of resistance incorporated to brown rust

(*P. recondita*) prevalent in Eastern India by breeding researches over Kalyan Sona and Sonalika (Check).

Materials and Methods

The material used for present investigation comprised of 15 wheat varieties including two check lines (Kalyan Sona and Sonalika) which were obtained from wheat genetic stock, Directorate of Research, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad. The field experiment (1x5m) was laid down in the randomized block design with four replications at Experimental Research Farm, Department of Genetics and Plant Breeding, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad. Each plot consisted of 4 rows, 1x5m plot size with plant geometry of 25x5cm. All the recommended cultural practices were followed during the crop growth period. For protein analysis, first primary grain samples were collected from each replication and from this primary sample, working grain sample lots were made which were subjected to grain protein estimation that was done as per the method suggested by Lowry *et al.* (1951) [13]. After observing the protein content percentage of each wheat variety, their protein estimation difference over the check was determined according to the following formula (Gomez and Gomez, 2010) [12].

$$\overline{X}_1 - \overline{X}_2$$

Where $\overline{X}_1$ = Mean protein content of variety

$\overline{X}_2$ = Mean protein content of check

Protein percentage increase/decrease over the check was determined according to the following formula (Andrew, 2001) [2].

$$\frac{\overline{X}_1 - \overline{X}_2}{\overline{X}_2} \times 100$$

Where $\overline{X}_1$ = Mean protein content of variety

$\overline{X}_2$ = Mean protein content of check

On the basis of CD (0.5%) values, the significant and non-significant performance of 13 semi-dwarf wheat varieties for grain protein content over two checks (Kalyan Sona and Sonalika) was determined by using the following formula (Gomez and Gomez, 2010) [12]:

$$\text{CD value} \pm \overline{X}_2 = \overline{X}_3$$

Where, $\overline{X}_2$ = Mean protein content of check

$\overline{X}_3$ = Estimated value

Estimated value was compared with mean protein value of variety, if estimated value recorded below the mean protein value of variety then mean performance of variety for protein content percentage is considered to be significant over check and if estimated value exceeds the mean value of variety then mean performance of variety for protein content percentage is considered to be non-significant over check.

The infection of rust was checked and measured on each plot and on the basis of intensity of infection (percentage of leaf area infected) plants were grouped using the scale developed by U.S. Department of Agriculture (Herbert *et al.* 1955) [9] into highly resistant (HR-0% infection), resistant (Traces, 1-10%), moderate resistant (MR, 11-20%), moderate susceptible (MS, 21-30%), susceptibility (S, 31-50%), highly susceptible (HS, 51% to above.

Results and Discussion

The data on mean estimation of protein percentage of 15 semi-dwarf wheat varieties including two checks (Kalyan Sona and Sonalika) have been summarized in Table 1. The perusal of the protein data indicated that K-816 contained the maximum amount of protein (12.40%) among the 15 varieties studied in this experiment including checks (Kalyan Sona (11.90%) and Sonalika (11.78%). However, the percentage increase in protein content of K-816 is hardly 4.20% over Kalyan Sona and 5.26% over Sonalika. The next high protein yielding variety was K-9533 (12.30%) followed by PBW-343 (12.28%) but increase in the protein content of K-9533 and PBW-343 over Kalyan Sona is just 3.36% and 3.19% and 4.41% and 4.24% over Sonalika. Raj-3777 (-6.38%, -5.77%), UP-2594 (-5.88%, -4.92), HD-2009 (-4.78%, -3.82%), Raj-4037 and HD-2824 (-3.02%, -2.03%) were found inferior contents than Kalyan Sona and Sonalika (checks) in their protein percentage. It is evident (Table-1) that none out of the high yielding semi-dwarf wheat varieties showed significant improvement in the mean protein content over Kalyan Sona and Sonalika. It appears that quality aspect has remained untouched by the wheat breeders. Harish (2001) [8] reported that the protein content in Indian wheat ranged between 11 and 12%, as against over 13% in Australian or North American wheat's. Shashi *et al*, (2004) [15] confirmed that wheat varieties from Punjab, Haryana, Uttar Pradesh, Bihar and Madya Pradesh have 11-12% protein content. Thus, our observations are in conformity with Harish (2001) [8] and Shashi *et al.* (2004) [15]. Since 90% of semi-dwarf wheat varieties released in India are selection/introduction of elite lines evolved at CIMMYT, Mexico (Nagrajan, 2005) [14]. It appears that even at CIMMYT Mexico, no attempt was made to improve the protein content beyond 11 to 12% in the newly evolved wheat varieties.

Out of the three wheat rusts diseases, only leaf rust (*Puccinia recondita*) is a great problem in eastern U.P. Every year leaf rust infection starts by the first week of March and continues up to full March and cause about 10-15% loss in yield. Among the 15 varieties tested, only HUW-318 (21.24%), Veeri (21.25%) and K-816 (21.27%) showed moderate susceptibility to leaf rust (Table-2). Among two checks, Kalyan Sona also showed moderate susceptibility (21-23%) whereas Sonalika showed moderate resistance (11-16%) to leaf rust. All other wheat varieties were free from even traces of infection. It appears that all the newly semi-dwarf wheat varieties released after Kalyan Sona and Sonalika possess reasonably fair degree of resistance to the leaf rust race flora prevalent in eastern U.P. This indicates that major attention has been paid to incorporate leaf rust resistance in the wheat breeding programme and during selection in breeding nursery as well as from entry to the promotion of new lines/genotypes from initial evaluation trial to uniform regional trials under AICWIP, the entries/lines having yield at par with check but resistant to the leaf rust were considered for promotion as a policy matter. A principal reason for the progress has been the number of trained individuals working on the problem in each wheat zone. This collective effort of plant pathologists and plant breeders in developing resistant cultivars and understanding disease epidemiology has gradually reduced the magnitude and frequency of epidemics. Use of knowledge of pathogen variability generated thus far, formed the basis of a strategy for deployment of resistance genes in the field. The emergences of new races of rusts require continued efforts to deploy new resistance genes. It is obvious that gene management in the field has considerable promise for sustained control of rusts. The current status of rust resistance breeding involves both conventional and molecular breeding approaches including QTL mapping. Efforts are being made since a long time to utilize wild relatives to develop novel germplasm. Wild species *viz*., *Ae. speltoides* (Dhakate, 2002) [6], *Ae. triuncialis* (Aghaee *et al.* 2001) [1], *Ae. Ovata* (Dhaliwal *et al*. 2002), and *Ae. umbellulata* (Chunneja *et al*. 2008) [5] have been exploited for leaf rust resistance. Useful genetic diversity is being continuously harnessed from wild relatives of wheat to diversify diseases resistance in wheat (Vinod *et al*. 2009) [17].

On the basis of the present investigation, it may be concluded that no significant improvement has been achieved in protein percentage through breeding research. Protein content differences between the latest wheat varieties over the first series of semi-dwarf wheat varieties Kalyan Sona and Sonalika has been very marginal. Of course, major attention has been paid to incorporate the resistance to leaf rust. Almost all the latest wheat varieties have shown a good degree of resistance to leaf rust disease.

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